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BACTERIAL DISEASES IN RICE AND THEIR ECO-FRIENDLY MANAGEMENT

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ABSTRACT

Rice (Oryza sativa L.) is commonly cultivated crop in India as well as over the world. Rice is prone to many diseases, among them bacterial diseases are most destructive which cause significant yield loss. Main bacterial diseases such as Bacterial leaf blight (BLB) of rice (Xanthomons oryzae pv. oryzae), bacterial leaf streak (BLS) (Xanthomonas oryaze pv. oryzacola) and bacterial panicle blight (BPB) (Burkholderia glume) have regular occurrence. On the basis of diseases severity and economic losses BPB, BLB and BLS are most destructive respectively reported by many researchers. Management of such disease is a challenge without harming environment and human health. Dumping of lot of chemicals having adverse effect on natural ecosystem and not economically feasible. In this review management of such diseases by eco-friendly approach is discussed. Adopting such practices is helpful in maintaining cost benefit ratio by resulting in profit. These practices can reduce the harmful residual effect of the chemical. It also suggests at about adopting effective cultural and physical method.

Keywords: Oryza Sativa, Xanthomonas Oryzae Pv. Oryzae and Burkholderia Glumae, Xanthomonas Oryzae Pv. Oryzacola & Eco-friendly Practices

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Original Article

INTRODUCTION

Rice is one of the cereal crops of great significance in India and primary staple food for huge population in Asia, Africa and Latin America. Consumption of rice accounts for over 90% of the world's population in Asia, with China, India and Indonesia producing 30.85%, 20.12% and 8.21%, respectively of total global rice production (USDA, 2012; Kadu, *et al.*, 2015). In India rice covers about 23.3% of gross cropped area of the country and plays a vital role in the national food grain supply. It puts up 43% out of total food grain production and for total cereal production 46% of nation. India secures second position in production of rice among all rice producing countries, China leads the highest production. The world area, production and productivity in 2014-15 were 162.2 Mha, 483.3 million tones and 4.44 MT/ ha, respectively. In India, rice is being grown in 44.10 Mha area with production of 106.5 million tones and productivity of 3.52 MT/ha, respectively (USDA. 2016). 56 fungal pathogens were reported that infects rice in 1985 by Ou, among them 41 were described to be seed-borne (Richardson, 1979, 1981). The global losses due to seed-borne diseases are estimated at 12% of potential production (Agarwal and Sinclair, 1987). If untreated seeds are grown in the field then seed-borne pathogen reduce the crop yield up to 15-90% (Zafar, *et al.*, 2014). It is prone to many diseases, among them bacterial diseases are most destructive which cause significant yield loss. Main bacterial diseases such as Bacterial blight of rice (*Xanthomons oryzae* pv. *oryzae*), bacterial leaf streak (*Xanthomonas oryaze* pv. *oryzacola*) and bacterial panicle blight (*Burkholderia glume*) have regular occurrence.

Eco friendly measures aim to reduce the harmful chemicals and reduction of dumping of such chemicals. Application of basic principal of management can be helpful in protection of crop and environment. Only when disease is above economic threshold level then only chemicals should be applied. This will also promote the survival of natural enemies of harmful bacteria in ecosystem. In such aspects strategies for integrated pest management should be included. These practices will not only reduce the chemical but also will be cost friendly. Hence we can conclude adoption of ecofriendly measures is sensible way of managing the sustainable agriculture and ecosystem.

Bacterial Leaf Blight (BLB)/White Withering Disease

- **Causal Organism:** Xanthomonas oryzae pv. oryzae (swings et al.1990**)**
- **Classification (KPCOFGS pv)**
  - Bacteria>Proteobacteria>**γ**-proteobacteria>Xanthomonadales>Xanthomonadaceae>Xanthomonas**>**oryzae**>**oryzae
- **Cryptogram**: G^{-ve}: Rode shaped/ Monotrichous: 6-8µm/ Non-spore forming: Pigment-Xanthomonadin/ colony-Round, Convex, Entire, Mucoid: 1-2x 0.8-1 µm.
- **Quarantine Status** - A.

Geographical Distribution and Economic Loss History

Bacterial leaf blight incidence has been increased due to extensive cultivation of dwarf high yielding variety especially in South- East Asia (Ray & Sengupta, 1970; Shivalingaiah and Umesha, 2011, Zhou *et al.*, 2013). It is also one of the oldest recorded rice diseases. This disease was first noted by the farmers of the Fukuoka area, Kyushu, Japan in 1884 (Tagami and Mizukami, 1962).Japan has also encountered loss of 22 000-110 000 MT in 1954(Paul and Smith 1989). The presence of disease was reported in1951 whereas epiphytotic appeared in1963. In the Philippines losses were also reported in resistance crop up to 9.5%in wet condition whereas for susceptible crop loss was high as 22.5%in wet and 7.2 in dry condition. (Exconde *et al.*, 1973).

Symptom and Sign

BLB is a vascular disease. The bacterium ends up in the xylem tissues, where it multiplies and moves throughout the plant. Seedling wilt and Kresek *phase:* It also called as sudden wilting and death of plant due to early systemic infection of seed or seedlings Leaves show wilting and upward rolling and change colour from grayish green to yellow. Youngest leaf develops broad yellow stripe and uniform. Older leaves develop no or less symptoms. Finally entire plant wilts and dies. *Leaf blight phase:* Initially Water-soaked lesions appear later it extends to yellowish stripes on leaf blades or starting at leaf tips. Characteristics symptom is development of wavy margin and milky bacterial ooze on young lesions especially early in the morning (**Figure.1**).finally lesion turn yellow to white ultimately complete plant dries. Saprophytic fungi growth gives it grayish appearance (Ou, 1985).

Figure 1: 1-Minute Yellow Droplets of Bacterial ooze, 2-Dried Bacterial Ooze on Leaf, 3-Dried Leaf from Margins

Disease Cycle

The primary inoculums of disease in rice crop occur due to *Xoo* infected rice planting seed, stem, left out after harvest, and alternate weed hosts (Durgapal, 1983). Primary inoculum probably moves plant to plant in most possible way by irrigation water, flood or storms. The bacterium enters through hydathodes or by wounds on the roots or leaves. It can also penetrate through stomata and build up ooze that again enters through hydathodes to continue cycle. Vascular system is important for Bacterium multiplication from where it moves systemically throughout the plant. *Xoo* grows in the plant and infects the plants leaf veins as well as the xylem causing blockage and plant wilting. Dissemination takes place mainly by flood and irrigation and up to some extent by wind (Dath and Devadath, 1983). Study on spread pattern in a rice field also been conducted (Reddy and Nayak ,1974). Transmission through seed up to certain extent is also reported (Hsieh *et al.*, 1974).

Epidemiology

Primary inoculum present on collateral, alternate, volunteer host and infected seed are key sources to the spread of disease and has the ability to spread the bacterium through a rice patty. Inoculum availability, level of N applied, planting density and crop growth stage also play a role in determining the severity of disease but because it promotes more vegetative plant growth and humidity retains longer but does not show effect on size of lesion when weather is dry. Secondary inoculum, bacterial ooze will cause infection on new host. Most faourable temperatures for *Xoo growth* ranges from 26-30°C and 20°C is ideal temperature for initial multiplication and growth. *Xoo* can tolerate pH range starting from 4 to 8.8 and best pH observed is 6-6.5 (Mizukami and Wakimoto, 1969).

The phage population increases much in advance of disease occurrence therefore; this has been utilized to forecast BLB occurrence in Japan (Tagami *et al.* 1958). Inoculation of phase in nurseries, the number of phages detected is generally less than 30 CFU / mL. When the pages population exceeds 100CFU /mL, seedling infection begins. At mid tillering, the phage population is <50 CFU /mL disease to be slightly, >100 CFU / mL, moderately and if >1000 CFU / mL disease become severe form. At maximum tillering, if the phage population in the rice field water is < 100 CFU / mL the disease going to be slightly, >500 CFU / mL-moderately and if >5000 CFU / mL- Severe form (Tagami and Mizukami

1962, Wakimoto *et al.*, 1987 and Watanabe 1975).

Bacterial Leaf Streak Disease (BLS)

- **Causal Organism:** *Xanthomonas oryzae* pv. *oryzicola* (Fang *et al.*) Swings *et al.*
- **Classification(KPCOFGSpv)**
  - o Bacteria>Proteobacteria>γproteobacteria>Xanthomonadale>Xanthomonadaceae>*Xanthomonas*>*oryzae*>*oryzae*> *oryzicola*
- **Cryptogram:** G^{-ve}: Rode shaped/ Monotrichous: 6-8µm/ Non-spore forming: Pigment-Xanthomonadin/ colony-Round, Smooth, domed, Entire, Mucoid: 1-2.5 x 0.4-0.6 µm/
- Quarantine Status - A1

Geographical Distribution and Economic Loss History

Bacterial leaf streak occurs in areas with high temperature and high humidity. Infected leaves, water that harbour bacteria our left over plant part or debris ofX. *oryzae* pv. *oryzicola* serve source of disease in healthy crop in the water, or in the debris left after harvest. It occurs mainly in Asia, Africa, South America, and Australia, Bangladesh, Cambodia, China where tropical and subtropical conditions are prevalent. In India disease distribution is found in Bihar, Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh another countries are Indonesia, Lao, Myanmar, Nepal, Pakistan, Philippines, Thailand, Malaysia, Viet Nam, Madagascar (Buddenhagen, 1985), Nigeria, Senegal, Australia. Easily recovery of mature rice plants from leaf streak and have minimal grain yield losses. Report of average yield loss due to bacterial leaf streak recorded as 8−17% and 1−3 % in the wet and dry season respectively. It does not usually reduce yields if low rates of Nitrogen are applied. 5-30% losses have been reported from India, while in the Philippines losses were not considered significant in either wet or dry seasons (Opina & Exconde, 1971).

Symptom and Sign

Bacterial leaf streak disease is a foliar disease. Appearance of fine, water soaked to translucent inter veinal streaks is the sign of disease which may be as long as 1 to 10 cm. These streaks are restricted by the veins and soon turn yellow or orange brown. Minute, yellow or amber beads of bacterial exudates are abundant on the streaks. When these beads dry, streaks or rough pustules may be felt on the leaf. These streaks may coalesce to form large patches and cover entire leaf surface. Eventually, the leaves may be completely blighted. In highly susceptible varieties streaks are surrounded by yellow halo. The infection may reach the leaf sheath and the seed coat but symptoms are not very clear (Ou. 1985)

Figure 2: 1-Initial Water-Soaked Lesions, 2-Enlarged and Merged Lesions

Disease Cycle

BLS mainly is a seed-borne disease. It can disseminate through seed, or also by plant-to-plant contact to some extent in its lifecycle. Presence of Moisture film facilitates discharge of the pathogen from the infected seed, which cause invasion inside tissue where it colonizes. Modes of entry of bacteria through openings on leaf surface, natural as stomata and induced such as wounds. Bacteria multiply in parenchyma tissue under favorable warm conditions ranges from 15^0c to $3^0$0c (IRRI, 1988). It Spreads bottom to top in the plant system. Symptoms develop as elongated streaks along the veins on leaf. Presence of dew or Water on leaves during infection increases number of lesions because of spread of bacteria accelerated. Bacteria overwinters in the soil where crop debris is present a. Primary spread occurs by seed hence cause infection in healthy seed (Tillman *et al.*, 1996). The bacteria will overwinter on other perennial plants and weeds in some cases.

Epidemiology

Main incidence of disease is occurred due to infected seed (Primary inoculums). However in severe infection it spread through the bacterial ooze carried by wind splashes, insects or pollinator. It also gets serious when high dose of nitrogen is applied. BLS is prominent in wet season and temperature has less relation to the disease severity compare to the wet condition which play key role in spread of disease. Humidity is (74-94%) with 26-30°C mean temperature also it rapidly spreads in the young plants compare to old plants. BLS is not as severe as BLB. In BLS primary inoculums is determinant of disease occurrence in the field which is carried through the planting seed and secondary spread is not main cause of epidemic hence quarantine for the seeds before planting is most successful rather than forecasting program. There is several models of forecasting for BLB is available than BLS (Shekhawat *et.al*, 1972, Mizukami and Wakimoto, 1969).

Bacterial Panicle Blight Disease (BPB) or Bacterial Ear Blight (BEB) or Bacterial Grain Rot (BGR) of Rice

- **Causal Organism:** *Burkholderia glumae* (formerly *Pseudomonas glumae*)
- **Classification (KPCOFGSpv)**
   - Bacteria>Proteobacteria>γproteobacteria>Burkholderiales>Xanthomonadaceae>*Xanthomonas*>*oryzae*>*oryzae*>*oryzicola*
- **Cryptogram:** G-ve: Rode shaped/ Monotrichous: 6-8µm/ Non-spore forming: Pigment- toxoflavin, non-fluorescent / colony-Round, Smooth, domed, Entire, Mucoid: 1-2.5 x 0.4-0.6 µm.

Kurita in 1967 first named this bacterial pathogen as *Pseudomonas glumae* which causes rice grain rot (Kurita and Tabei, 1967). Since 1992, the non-fluorescent bacteria in *Pseudomonas* are classified as genus *Burkholderia* and the others. And therefore, *Pseudomonas glumae* is renamed as *Burkholderia glumae* by Walter H. Burkholder, plant pathologist at Cornell University in 1992 (Yabuuchi *et al.*, 1992). The genus was named after Walter H. Burkholder, plant pathologist at Cornell University. It shows optimum growth at around 30 °C temperature, but it can grow even at 41 °C (Saddler, 1994).

Geographical Distribution and Economic Loss

Bacterial panicle blight was first reported in the Kyushu district of Japan in 1956, it was seen in Colombia in 1989, later it has became significant serious rice diseases among other diseases of rice in the world (Xie *et al.*, 2003). Since then BPB is reported from many rice growing countries like South and Central America which includes Dominican Republic, Venezuela, Panama Ecuador, Brazil, Colombia, Costarica, Nicaragua and in Africa mainly Tanzania South Africa. Whereas in as Asia it is wide spread in most of the countries like China, India, Japan, Sri Lanka, the Korea, Indonesia, Philippines Malaysia, Vietnam Thailand. (Tsushima, 1996, Nandakumar *et al.,* 2005 *and* 2007, Wang *et al.*, 2006,Kim *et al.*, 2010, Quesada-González and , Riera-Ruiz *et al.*, 2014, García-Santamaría, 2014, Zhou, 2014 and Mondal *et al.*, 2015). In sever bacterial panicle blight incidence it can encounter yield loss up to 75% (Trung *et al.*, 1993). It imposes potential high risk in tropical and sub tropical countries (Ham *et al.*, 2011).

Symptom and Sign

Reports of symptoms of BPB on the leaf, flag leaf sheath and panicle florets were recorded in Louisiana. Characteristics symptoms develops as necrotic brown colour lesion having distinct margin on leaf. It appears as stripe on leaf, browning of flag sheath and grain rot (**Figure 3**).bottom half of floret turn brown and Spikelet develop grayish or straw-colored discoloration. Sterile florets and seedling blighting observed (Shahjahan, 2000b).

Figure 3: 1-Water Soaked Discoloration on the Lower Part of the Grains, 2-Infected Panicles Upright Heads, 3-Leaf Sheath Rot Symptoms

Disease Cycle

It is mainly seed born disease but sometimes inoculums can also survive in soil (Goto and Ohata, 1956, Uematsu *et.al.,* 1976). In matured plant inoculums can also survive in leaf sheath and panicle it grows epiphytotically from booting stage (Sayler *et al.*, 2006). It disseminate in population from infected plant to another plant. However disease cycle is not completely known. Plants which is sown using infected seed in that symptoms develops as plant grows ultimately affect flowering stage and grain filling (Ham *et al.*, 2011).

Epidemiology

In rice growing period if favorable condition such as warm night temperature and more humidity prevails then it leads to the higher chances of disease incidence (Cha *et al.*, 2001). Most susceptible stage for BPB infection is rice heading stage followed by warm nights and frequent rainfalls. Presence of inoculums combine with favorable environmental conditions leads to disease outbreak. In such condition spread of disease so rapid because more build up of bacterial population (Xie, et al 2003). Discovered that *B. glumae* can cause spikelet sterility and the discoloration of emerging grains. Pathogen cells present on leaf sheaths play an essential role in primary infection. Infection on the leaf sheath provides the primary source of inoculum to the emerging panicle (Tsushima *et al.*, 1991 and Tsushima *et al.*, 1996). The primary infection site by *B. glumae* is apparently through the plumules (Hikichi, 1993a; Hikichi, 1995b). Important site of bacterial invasion is lemma and paleae enters through stomata where it multiplies in parenchymatous intercellular spaces (Tabei et al, 1989), and then it further infects surrounding healthy tissues of host. The bacteria were reported in the epidermis, parenchyma, and sclerenchyma of glumes of naturally infected rice seeds where antiserum used (Hikichi, 1993b). The long-distance movement of bacteria was accomplished via vascular systems. *B. glumae* instead of florets sterility, seedling failure and seed germinaton inhibition it also cause most economic damage that is reduced grain weight (Jeong et al, 2003). The temperature optimum for growth observed of *P. glumae* was 30-35C with a range of 11-40°C and 70°C as thermal death point (Kurita *et al.*, 1964).

Intergrated Disease Management

- Primary inoculum, in seed eradicate by hot water treatment at 57ºC for 10 minutes (Tagami and Mizukami, 1962)
- Seed soaking overnight in 100ppm streptocycline solution (Devadath and Padmanabhan, 1970).
- Seed soaking in 0.025% streptocycline and hot water treatment at 52ºC for 30 min are effective in eradicating the seed infection.
- Practicing field sanitation such as removing rice straws, alternate, collateral and volunteer plant is important to avoid infection.
- Use of wider spacing (30x15 cm).
- Avoid clipping of tip of seedling at the time of transplanting.
- Proper irrigation and drainage.
- Proper application of nitrogenic fertilizers.
- Grow resistant varieties like IR-20, IRBB21, IR-36, Sasyasree, Govind, Pant Dhan-4,Pant Dhan-6, Saket-4, Rajendra Dhan 200, Pusa-2-21, Ratna CR-10, IR64, IR72, Minghui 63 BG 90-2 etc. against BLB, Blade, Cromwell, Faller, Howard or Knudson, IR-20, Krishna and Jagannath have shown good tolerance to BLS and moderately resistance cultivar Jupiter against BPB.
- Spray fresh cow dung extract 20% twice (starting from initial appearance of the disease and another at fortnightly interval)
- Spray application of Neem oil 60 EC @3% or NSKE @5% for disease control.
- Application of *P. fluorescens* includes wet seed treatment (ST) @ 10g per kg of seed; Soil application (SA) @ 2.5 kg/ha basal along with 50 kg of well decomposed FYM and Foliar spray @ 0.2 per cent on 60 and 75 DAS (Jeyalakshmi 2010).
- Using of Streptocycline @ 100 µg a.i./*l*,or Agrimycin-100 @ 100 µg a.i./*l* (Banerjee *et.al.,* 1984), Oxolinic acid @ 300 µg a.i./*l* or streptomycin sulfate @ 100 µg a.i./*l*, glycocide B @ 700 µg a.i./*l*, kasugamycin @ 80 µg a.i./*l* (Shtienberg *et al.,* 2001) recommended 3 spray at intervals of 10 days starting from the earliest appearance of the disease.
- Application of *Streptomyces toxytricini, Bacillus subtilis* var. *amyloliquefaciens, Pseudomonas floroscence* and *Lysobacter antibioticus* includes wet seed treatment (ST) @ 10g per kg of seed (Velusamy *et al.,* 2006, Ji *et al.,* 2008, Nagendran *et al.,* 2013, Hop *et al.,* 2014, Sharma *et al.,* 2015).

CONCLUSIONS

The major challenge in production /cultivation from Biotic point of view is imposed by Bacterial disease such as BLB, BLS and BPB. To overcome these challenge Farmers and Growers started indiscriminate use of chemical pesticide. It has not only destroyed the balance of natural system but also imposed health risk to the humans and animals. Resistance against such chemicals has also been reported. Complete dependence on Biological control is also not practical.

Hence considering all above challenges we tried to combine maximum possible minimum/non chemical approaches in one plate form which earlier was scattered or confined to the only Research. This review suggests some eco-friendly management approach for significantly important and serious bacterial diseases. Eco-friendly approaches not only will reduce chemical usage but also will insure good yield and low input cost. As an ecological point of view it will also be useful in bringing harmony between natural and artificial Ecosystem. If it is adopted for long term then there will be less chance for development of Biotype and less frequent depletion of diversity. It will be more effective when all this recommendations are considered starting from pre sowing to harvesting and storage to insure low chances of disease development (or) at least to maintain it to below Economic Injury Level/ Economic Threshold Level.

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